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(54) SELF-HEALING ELECTRIC THIN-LAYER CAPACITOR AND METHOD OF PRODUCING IT

(71) We, HIRADCSTECHNIKAI IPARI KUTATO INTEZET, a body corporate organised under the laws of Hungary, of 67, Vorosmarty-U., Budapest VI, Hungary, do hereby declare

the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement: —

The invention relates to a self-healing electric thin-layer capacitor and a method of producing it.

In apparatus in the production of which transistors are widely employed, the circuits which are primarily integrated or micromodule circuits, require electrical components of small (subminiature) dimensions, of low service voltage and high reliability, including capacitors. From the viewpoint of miniaturisation and operating reliability, an increase in the self-healing ability is an important requirement in capacitors.

In known capacitors constructed with self-healing metal foils and with paper or plastics dielectrics, the material of both electrodes is identical and they are symmetrically disposed about the dielectric. In the event of a disruption, that part of the electrode which forms a closure escapes out of the region of the fault in the form of metal vapour without damaging the dielectric. However, such capacitors cannot be employed in integrated or micromodule circuits owing to their relatively large dimensions.

There have therefore been developed for this purpose capacitors evaporated on the support and having thin electrodes and thin dielectrics, wherein the metal layers of the electrodes, which have approximately or absolutely equal melting points, are produced by vacuum vapour coating or cathode sputtering, while the dielectric layer is produced by anodic oxidation as well as by the aforesaid two methods. The support material consists of glass, ceramic bodies with or without glazing, or of plastics.

In these known thin-layer capacitors, the two electrodes differ substantially from one another in their arrangement. One electrode is enclosed between the support and the layer of dielectric, while the other is disposed above the dielectric.

The self-healing ability during operation of these known thin-layer capacitors, however, is limited because both the electrode situated between the support and the dielectric and the electrode situated above the dielectric are formed by metal layers of equal or approximately equal melting point, so that in the course of the self-healing process effected during the production or operation the lower and upper metal layers simultaneously melt under the action of the heat evolved at the faults due to the disruptions owing to the applied voltage, and at the place of the fault there arises a bulge from the molten material of the lower metal electrode. This bulge, which is only a few microns thick, causes cracks in the dielectric, whereby contact or alloying of the two metal layers may result in an irreparable short-circuit. This effect also occurs due to the higher voltages or currents set up during operation, for example in arrangements operating with coding pulses, whereby the operating reliability is substantially impaired.

A self-healing electric thin-layer capacitor, particularly for integrated and micromodule circuits, according to the invention comprises a support wafer to the surface of which a first or lower high-purity aluminium electrode, is applied on the surface of which electrode a dielectric layer, such as aluminium oxide layer is formed, wherein a second or upper electrode layer formed of a metal or an alloy of lower melting point than the first electrode layer, is applied to the dielectric layer.

In a particular form of the subject of the invention, the electrode formed on the upper surface of the dielectric consists of cadmium,

[*Price 5s. 0d. (25p)*]

indium, tin, antimony, lead, zinc or an alloy thereof.

In accordance with the invention, the electrodes may be produced by vacuum vapour coating or cathode sputtering and the dielectric layer may be produced by moist anodic or gas discharge plasma oxidation.

Any disruptions occurring either in the course of the production during the electrical forming—that is the cleaving of shorts and faults of the dielectric layer during operation first melt the metal of the second, i.e. upper, electrode at the instant of the disruption, this action being gradually propagated in ring form away from the fault, while the first—i.e. lower—electrode situated between the support and the dielectric only melts to a very small extent. Consequently, a no bulge of metal can be formed between the support and the dielectric, and therefore no cracks occur in the dielectric.

One form of construction of self-healing capacitor according to the invention and a method of producing it will be more fully described by way of example with reference to the drawings.

Figure 1 illustrates in sectional side view the capacitor according to the invention, and

Figure 2 is a plan view thereof.

An aluminium electrode 2 is produced on a glass support wafer 1 from a tungsten source in a vacuum of 10^{-5} mm.Hg. This aluminium layer, the melting point of which is about 659.7°C., forms the lower electrode of the capacitor. A dielectric layer 3 is produced in a thickness of 4000Å on the surface thereof either from aluminium oxide by anodic oxidation of the aluminium electrode surface in a glycol borate electrolyte, at a given voltage of, for example, 60 volts, or under a vacuum of 10^{-5} mm.Hg. by evaporation of magnesium fluoride from a molybdenum source. An upper electrode 4 consisting of indium having a melting point of 156.4°C. is applied to the upper face of the dielectric layer also by vacuum vapour coating under a vacuum of 10^{-5} mm.Hg. As will be apparent from the figure, the dimensions of this upper electrode 4 are smaller than those of the lower electrode 2. The contacts of the capacitor are formed from a silver suspension at the projecting portions, to which tin-plated copper wires are soldered. The finished capacitors are provided with a protective coating. The electrode 2 is provided with a lead-out 5 and the electrode 4 with a lead-out 6.

The thin-layer capacitor according to the invention renders possible electric forming or self-healing at the higher voltage employed. Within the aforesaid service voltage, the external dimensions of the capacitors may also be reduced, so that they are also very suitable for miniaturisation owing to the smaller dimensions which are rendered possible. With a given dielectric thickness, the insulation resistance of the capacitors is higher than that of those having like electrodes, since the area cut out is larger on the upper electrode than on the lower, so that the possibility of conduction through the defects occurring during the production is reduced. The possible waste in the process of manufacture is substantially reduced, whereby the economy is increased. In operation, the operating reliability factors of the sensitive electronic devices are enhanced.

WHAT WE CLAIM IS:—

1. Self-healing electric thin-layer capacitor, particularly for integrated and micromodule circuits, comprising a support wafer to the surface of which a first or lower high-purity aluminium electrode, is applied on the surface of which electrode a dielectric layer, such as aluminium oxide layer is formed, wherein a second or upper electrode layer formed of a metal or an alloy of lower melting point than the first electrode layer, is applied to the dielectric layer.

2. Capacitor according to claim 1 wherein the second electrode layer consist of cadmium, indium, tin, antimony, led, zinc or alloys of these metal.

3. Self-healing electric capacitors substantially as herein described with reference to and as illustrated in the accompanying drawing.

4. Method of producing the capacitor according to claim 1, 2 or 3, wherein the electrodes are produced by vacuum vapour coating or by cathode sputtering and the dielectric layer is produced by moist anodic or gas discharge plasma oxidation.

5. Method of producing a capacitor substantially as herein described.

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1210677 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

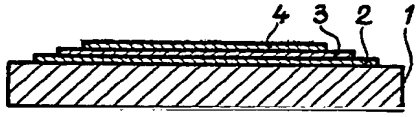

Fig. 1

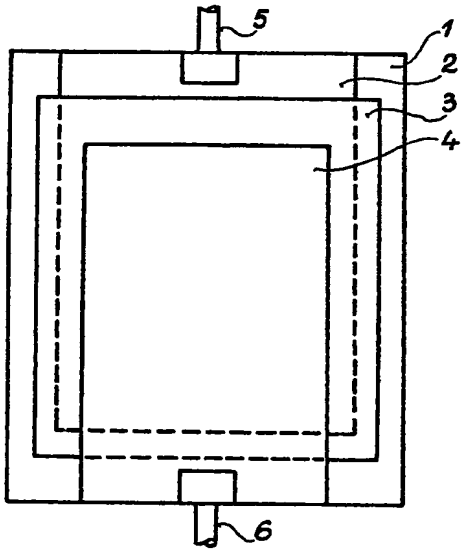

Fig. 2